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Problems and Techniques
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maintained or if *my* ideals are not preserved; and to prevent such occurrences *my* family members should participate in war.

It seems likely that the first two hypotheses mentioned above are the most relevant today but that if the same trends were found in more critical times, the latter hypothesis would be a more exact explanation for the same observable relationship.

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2. Problems and Techniques

Experiments in the Wording of Questions

THE IMPORTANCE of the wording of questions in public opinion polls was emphasized by Elmo Roper in the last issue of the QUARTERLY. In his article Mr. Roper stated that he had offered to test through his organization alternate wordings suggested to him by the QUARTERLY. The report below summarizes the first experiment on this problem.

Alternate wordings on two questions of current interest were chosen. In the first question one form used President Roosevelt's name, the other did not. In the second question Hitler's name was mentioned in one form but not in the other.

1(a). Do you approve of Sumner Welles' visit to European capitals?

1(b). Do you approve of President Roosevelt's sending Sumner Welles to visit European capitals?

2(a). Do you think the U.S. should do more than it is now doing to help England and France?

2(b). Do you think the U.S. should do more than it is now doing to help England and France in their fight against Hitler?

Two representative samples of the population, based on the criteria used by Roper for the *Fortune* surveys, were selected. Questions 1(a) and 2(b) were asked one group, questions 1(b) and 2(a) were asked the other group. Each group contained about 1550 persons. The survey was made during March 1940.

Welles' Visit

When President Roosevelt's name is used in connection with Mr. Welles' visit, two significant differences in total response are revealed: more people have opinions and, although the percentage of people who approve of the visit remains identical, more people disapprove of it when its initiation is attributed to Roosevelt. The percentages are:

	App.	*Disapp.*	*No op.*
1(a) [without Roosevelt]	43%	25%	32%
1(b) [with Roosevelt]	43	31	26

The President's name in this particular context, then, seemed to bring

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people from the "no opinion" column to the "disapprove" column.

Women were more affected in this direction than men: their "no opinion" vote was reduced by nine per cent, that of men by only three per cent. As one might expect, the introduction of Roosevelt's name decreased the "approve" vote and increased the "disapprove" vote most in the upper income group. In the lower income brackets, however, the opposite of this tendency is not found. There, too, the "disapprove" vote increases significantly, although a slight rise is also noted in the "approve" vote. In both forms of the question the "no opinion" vote increases very appreciably as the economic status becomes lower, indicating the puzzlement or ignorance of people in the lower cultural levels. The division of opinion within economic groups is given in Table 1.

The President's name clearly tends to crystallize opinion. But in this instance it is not a simple matter where a "no opinion" vote falls evenly in alternate answers. Here for various reasons opinion is drawn out primarily against the visit when Roosevelt is mentioned. A part of this is due to the general condemnation of upper income groups of anything the President does. But such groups represent only a small minority. A more important reason for the shift is possibly due to the fact that persons who have no opinion on this question are either ignorant of, or uninterested in, the visit, or have not pondered its possible significance. When the President's initiation is clearly indicated, however, a few of these people may construe the visit as aggressive, dangerous meddling, likely to involve the United States in the war which we know, from other poll results, the great majority want to avoid.

Helping England and France

When the overthrow of Hitler is clearly indicated as the Allied objective, nine per cent more people think the U.S. should increase its aid to England and France.

	Do more	*Do no more*	*No op.*
2(a) [without Hitler]	13%	75%	12%
2(b) [with Hitler]	22	66	12

The alternate wordings produce a slightly greater change of opinion in the expected direction among women, people over 40 years of age, and those in the lower income groups.

The "no opinion" vote in both forms of the question is lower for men, people in urban centers, and

TABLE 1

	Approve		*Disapprove*		*Don't Know*	
	1 (*a*)	1 (*b*)	1 (*a*)	1 (*b*)	1 (*a*)	1 (*b*)
Group A	50%	42%	33%	46%	17%	12%
Group B	52	46	29	34	19	20
Group C	43	45	25	33	32	22
Group D	37	38	22	27	41	35

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persons in the higher income group. However, *within* each group it remains essentially the same on both forms of the question. Hence in this question, as contrasted to the first one, a very definite shift in attitude occurs, presumably because the introduction of Hitler's name with the consequent awareness of an enemy to be destroyed, as well as friends to be helped, increases the intensity of the desire to see an Allied victory.

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Confidence Limits and Critical Differences Between Percentages

This is a technical supplement to Mr. Wilks' article which begins on page 261.

SUPPOSE a sample of n cases is drawn "at random" from a large population in which each individual is either an A or a B. For example, in a certain population to be polled on a given question, the individuals can be classified according to whether they answer "yes," "no," or "no opinion." We could refer to the "yeses" as A's and all others as B's. Suppose the "yes" percentage of the population is p. Now p is unknown and the purpose of polling by using a sample is to estimate it. In a sample of n cases a certain percentage $\bar{p}$ of the individuals will be "yeses." Suppose many such samples of n cases each are drawn. Each sample has its own percentage $\bar{p}$, and if the samples are all drawn under ideal random sampling conditions, these percentages will be clustered around the population percentage.

In view of this sampling fluctuation we cannot say in the case of a given sample that the value of the population percentage p is exactly equal to $\bar{p}$, but for any given probability level, say 0.99, we can calculate *confidence limits* from the sample percentage $\bar{p}$ and n the sample size, and say that the probability is 0.99 (or the chances are 99 out of 100) that the value of p in the population will be included between the confidence limits. For large n, say 50 or more, 99 per cent confidence limits of the population percentage p are approximately the two values obtained by solving the equation $n(\bar{p}-p)^2=6.64p(100-p)$ for p. If, for a given sample of size n, we regard the two confidence limits obtained in this way as being graphed for all values of $\bar{p}$ between 0 and 100, we get a pair of curves. Pairs of curves obtained in this manner for n=50, 100, 200, 500, 1000, 3000, and 10,000 are given in Chart I. Although these curves have been computed under the assumption of unrestricted random sampling, it can be shown that they are conservative confidence limits of a population percentage p under conditions of representative sampling roughly described on pp. 262-3 of this issue of the QUARTERLY; con-

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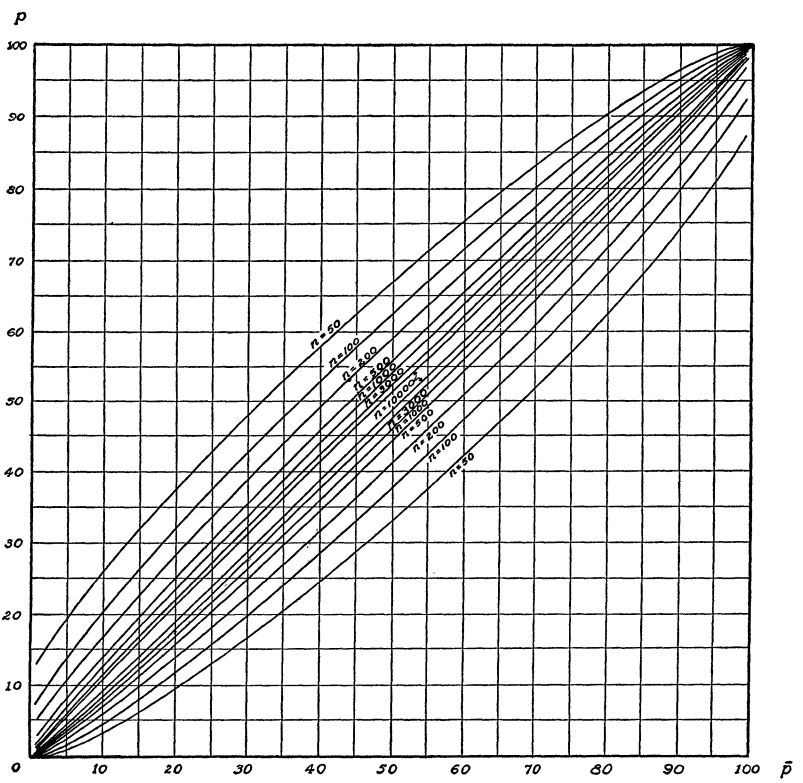
servative in the sense that the probability is at least 0.99 that the confidence limits for any given n and $\bar{p}$ will include between them the value of p in the population.[1]

As an example of the use of Chart I, suppose a representative sample of 1000 is drawn from a large population, and suppose 20 per cent of the people in the sample answer "yes" to a certain question. Using $\bar{p}$=20% in the chart and finding where the vertical line through 20 cuts the two

[1] This chart is based on the principles of fiducial inference which overcome certain difficulties inherent in the older "probable error" methods. A chart similar to this one has been published by E. S. Pearson and C. J. Clopper in *Biometrika*, Vol. 26 (1934). Theodore H. Brown of Harvard University has prepared a table showing the size of sample necessary, for several assumed values of the population percentage p, to produce various degrees of accuracy (in terms of deviations of three standard errors, or 0.997 probability level) in the control of sampling fluctuations of $\bar{p}$ around p.

Chart I



Curves giving 99 per cent confidence limits of a population percentage p corresponding to each value of the sample percentage $\bar{p}$ for sample sizes 50, 100, 200, 500, 1,000, 3,000 and 10,000.

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curves for n=1000, the two confidence limits are seen to be about 17 per cent and 23.5 per cent. If we apply this procedure to a great many samples, getting a pair of confidence limits each time, and making the statement in each case that the confidence limits include the population value between them, then, under ideal conditions of random sampling, about 99 per cent of our statements will be correct. Under conditions of representative sampling, at least 99 per cent of our statements can be expected to be correct in the long run.

Small Populations

In case the sample is a random sample from a fairly small population, there is not as much fluctuation of the percentage of A's in samples of a given size as in the case of samples of the same size from very large populations in which the percentage of A's is the same. The procedure which we have described for using Chart I can be slightly modified so as to hold approximately for the case of small populations. For small populations, the value which is used for n in Chart I is not the size of the sample but $N(M\text{-}1)/(M\text{-}N)$, where N=sample size and M=population size. For example, suppose the "yes" percentage is 30 per cent in a sample of 100 drawn from a population of 1000 (a college student body for instance). The quantity $N(M\text{-}1)/(M\text{-}N)$ has the value 111. This means that a sample of 100 from a population of 1000 is essentially equivalent to a sample of 111 from a very large population as far as degree of sampling fluctuation is concerned, assuming the same "yes" percentages in the two populations. As there are no curves for n=111, we make a rapid graphical interpolation by noting that curves for m=111 would be very close to the curves for n=100. Taking $\bar{p}$=30, we see that the confidence limits are about 20 per cent and 42 per cent.

Percentages Within a Sample

Suppose each individual answers "yes," "no," or "no opinion" to a given question in a poll. In general, the "yes" percentage in the sample will be different from the "no" percentage. In view of the fact that each of these two percentages is subject to sampling fluctuations, the question arises as to how large should be the difference between the two percentages before we can consider the sample difference as indicative of a genuine difference in the population.

As in the case of establishing confidence limits, we have to choose a probability level before we can answer the question. Let $\bar{d}$ denote the difference between the "yes" and "no" percentages in a sample of size n, and let d be the corresponding difference in the population. If samples of size n are drawn under random sampling conditions repeatedly from a population in which the "yes" and "no" percentages are p_1 and p_2 respectively, then in approximately 99 per cent of the samples, the difference $\bar{d}$ between "yes" and "no"

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percentages in the sample will not deviate by more than

$$\frac{2.58}{\sqrt{n}}\sqrt{100(p_1+p_2)-d^2}$$

from the difference between "yes" and "no" percentages in the population. In practice we do not know p_1 and p_2; if we did, there would be no point in sampling. The question to be settled is not how to set sampling limits on the difference $\bar{d}$ in repeated sampling from a population with a given difference d, but how to set confidence limits on a population difference d for a given sample difference $\bar{d}$.

Now, 99 per cent sampling limits of $\bar{d}$ are given by

$$d\pm\frac{2.58}{\sqrt{n}}\sqrt{100(p_1+p_2)-d^2}$$

that is, in drawing random samples of size n repeatedly from a population with "yes" and "no" percentages equal to p_1 and p_2, about 99 per cent of the samples have a difference $\bar{d}$ which lies between these two limits. This does not imply that if d, p_1 and p_2 are replaced by the corresponding sample values, the resulting two values will include the value of d between them in about 99 per cent of the samples, although this is the procedure currently followed in practice and the results are perhaps satisfactory for practical purposes. Even if these limits are used, a considerable amount of computation is required to set up a satisfactory set of working charts or tables because so many variables are involved.

A simple, conservative critical value of the sample difference $\bar{d}$ is given by $258/\sqrt{n}$. It can be shown that if $\bar{d}$ (taken as positive) is larger than $258/\sqrt{n}$ the probability is at least 0.99 that a genuine difference d between "yes" and "no" percentages exists in the population; or to put it more precisely, the probability is at least 0.99 that d would be included between two positive confidence limits. The value of $258/\sqrt{n}$ is definitely a conservative critical limit for $\bar{d}$, but it has the advantage of being simple and, even more important, it does not depend on the population percentages which are, in general, unknown.

The values of $258/\sqrt{n}$ for the various values of n can be graphed as a curve. This curve is marked P=.99 in Chart II. A similar curve (P=.95) is given for the 0.95 level of probability. The critical limit for this case is $196/\sqrt{n}$. To illustrate the use of Chart II, suppose the "yes" and "no" percentages to a given question in a sample of 3000 cases are 38 per cent and 32 per cent respectively. It is seen in Chart II that by taking n=3000, the critical difference is about 4½ per cent. Hence the 6 per cent difference in the sample can be regarded as significant at the 0.99 probability level.

Percentages in Two Samples

The problem of comparing two percentages within a single sample is different from that of comparing two percentages in different samples, due to the fact that two percentages within a single sample are negatively correlated, whereas there is no significant correlation between two per-

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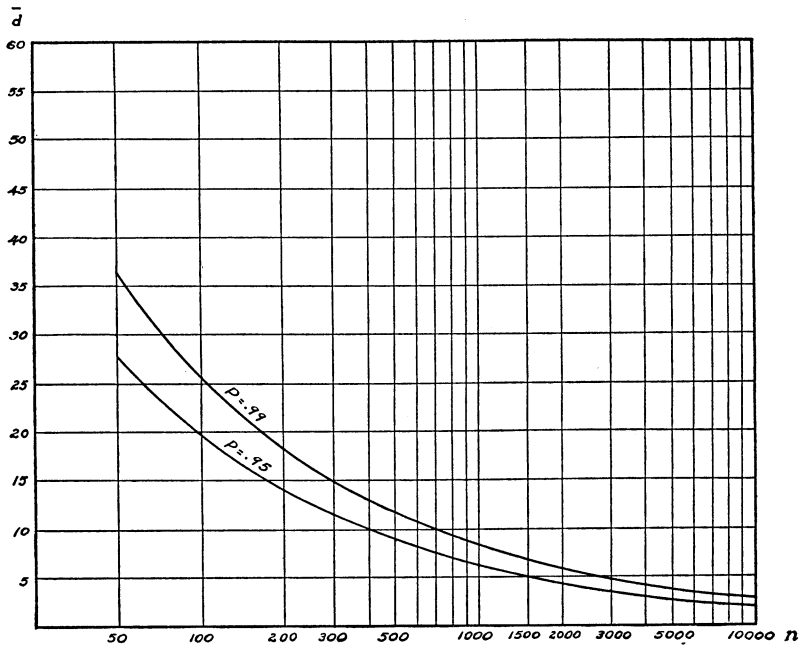
Chart II



Curves giving conservative critical limits of a difference between two percentages in the same sample for the two probability levels .95 and .99.

centages in two different samples. A discussion of the problem for two samples is entirely similar to that for the case of a single sample and will not be repeated, the essential difference being that

$$\sqrt{p_1(100-p_1)/n_1+p_2(100-p_2)/n_2}$$

is used in place of

$$\frac{1}{\sqrt{n}}\sqrt{100(p_1+p_2)-d^2},$$

where n_1 and n_2 are the two sample sizes.

The corresponding conservative critical limit for $\bar{d}$ in the two sample case[2] is $129\sqrt{(n_1+n_2)/n_1\,n_2}$. Critical values of $\bar{d}$ for several values of n_2 and values of n_1 from 50 to 10,000 are given in Chart III.

To illustrate the use of Chart III, suppose the "yes" percentage to a certain question in a poll of 3000 cases is 52 per cent, while the "yes"

[2] If instead of calculating $\bar{d}$, the difference of the two sample percentages p_1 and p_2, we calculate the difference

$$\bar{d}'=100(\sin^{-1}\sqrt{p_1/100}-\sin^{-1}\sqrt{p_2/100})$$

then $129\sqrt{(n_1+n_2)/n_1n_2}$ is an exact (not conservative) critical limit for $\bar{d}'$, to a close approximation, at the 0.99 probability level. Nomograms based on $\bar{d}'$ for testing the significance of the difference between percentages in two different samples have been prepared by Joseph Zubin, *Jour. Amer. Stat. Assn.*, Vol. 34 (1939), pp. 539-544.

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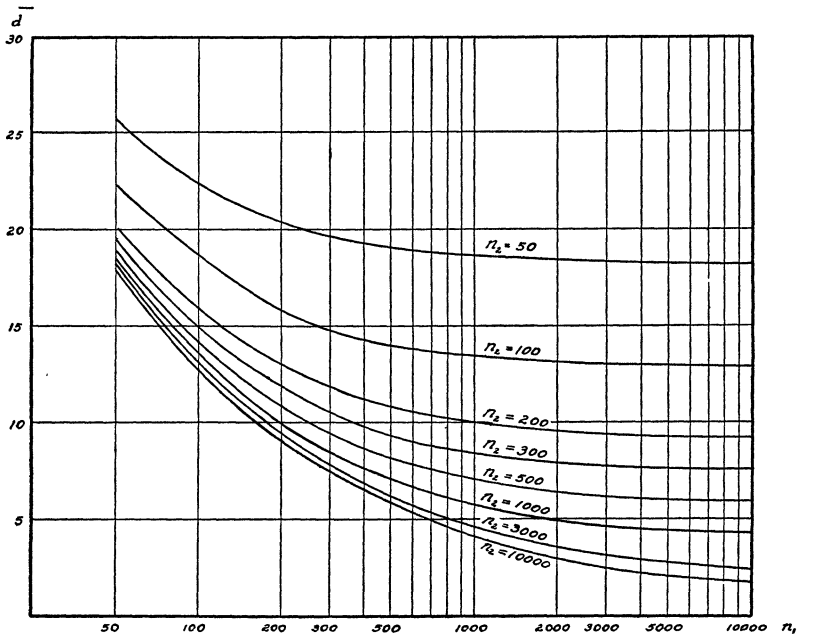
Chart III



Curves giving conservative critical limits of a difference between two percentages in different samples for the .99 probability level. If a more highly refined significance test is desired, $\bar{d}'$ as defined in footnote 2 should be used in place of $\bar{d}$.

percentage to the question in a second poll of 800 cases is 48 per cent. Taking n_2=3000 and n_1=800, it is seen that the critical difference is about 5 per cent. The sample difference of 4 per cent is therefore of doubtful significance at the 0.99 probability level.

The curves in Charts II and III are conservative for representative sampling in the same sense that those in Chart I are conservative. The use of Charts II and III can be extended to samples from small populations by following the same scheme of augmenting the sample size by using the formula $N(M-1)/(M-N)$ discussed in connection with the use of Chart I for samples from small populations. Although all of the charts, particularly II and III, are based on certain calculations which make them conservative in a sense already discussed, they should be used with a great deal of caution when very small "yes" (or "no") percentages (less than about 5 per cent) are involved, and also when samples of less than about 50 cases are involved.

Finally it should be emphasized

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again that the three charts are based on the assumption of unrestricted random sampling, and are conservative for representative sampling. They are not applicable when the sampling has been done incorrectly.

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[*Large-scale copies of the charts contained in this article will be prepared by the* QUARTERLY *and offered for sale to those who may wish to use them for rapid calculations of confidence limits and critical differences of percentages, if sufficient orders are received in the near future.*]

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